Project 1

ELM 361 Project 1

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Analog Communication Systems
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Electronic Engineering

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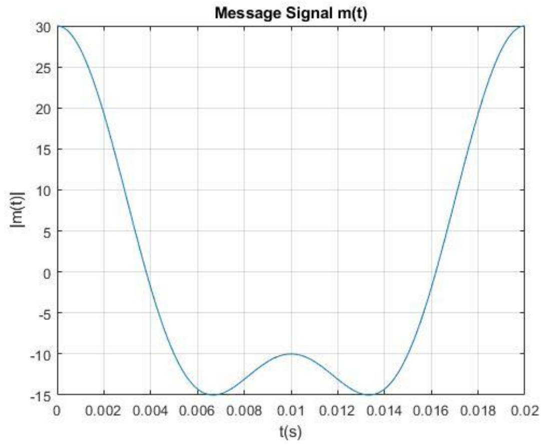
1) Plot the message signal for one period. Plot the spectrum of the message signal.

$$m(t) = 20\cos(100\pi t\ ) + 10\cos\ (200\pi t)\ c(t)$$

$$\mathrm{c(t)} = 100\cos\ (500\pi t)$$

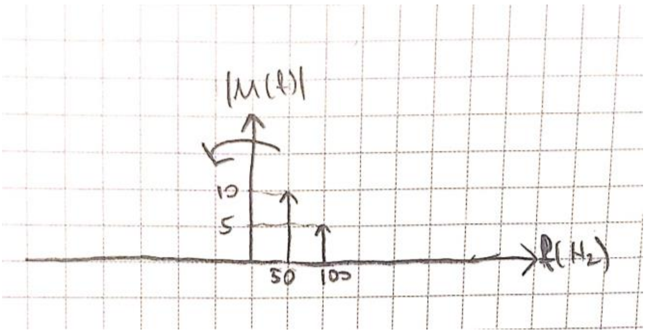
If the graph of m(t) is plotted on Matlab;



(Figure 1)

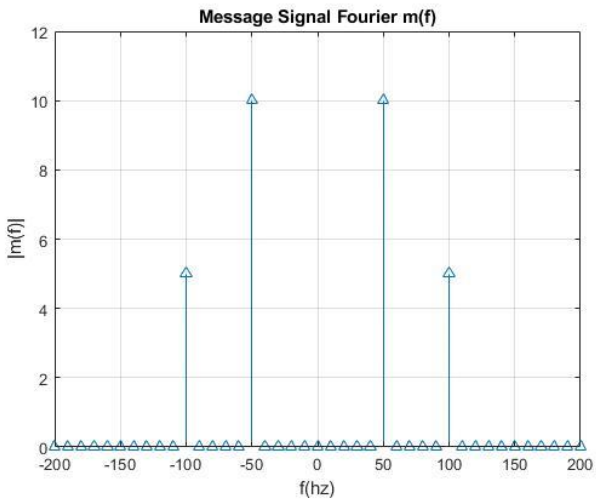
If the Fourier Transform of the m(t) signal is done;

$$M(f) = 10[\delta(f - 50) + \delta(f + 50)] + 5[\delta(f - 100) + \delta(f + 100)]$$



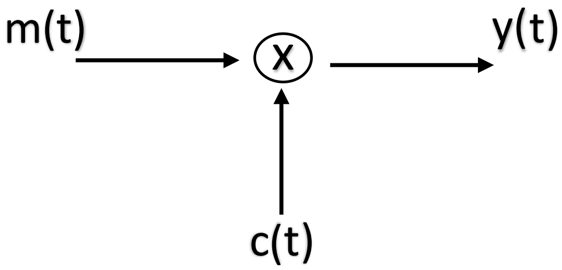
(Figure 2)

If the graph of M(f) is drawn on Matlab;



(Figure 3)

2) Plot the modulated signal $y(t)$. Plot the spectrum of $y(t)$.

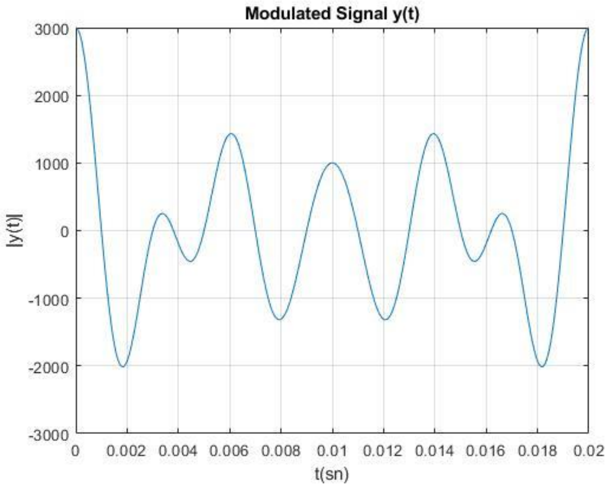


$$y(t) = m(t).\, c(t)$$

$$y(t) = 2000\cos(100\pi t)\cos(500\pi t) + 1000\cos(200\pi t)\cos(500\pi t)$$

$$y(t) = 1000[\cos(2\pi 300t) + \cos(2\pi 200t)] + 500[\cos(2\pi 350t) + \cos(2\pi 150t)]$$

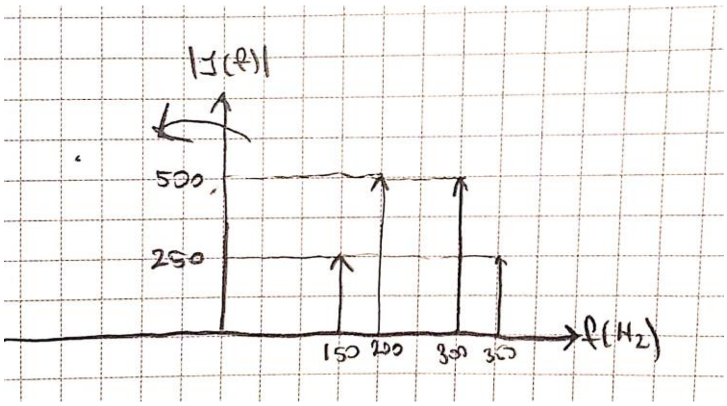
If the graph of y(t) is plotted on Matlab;



(Figure 4)

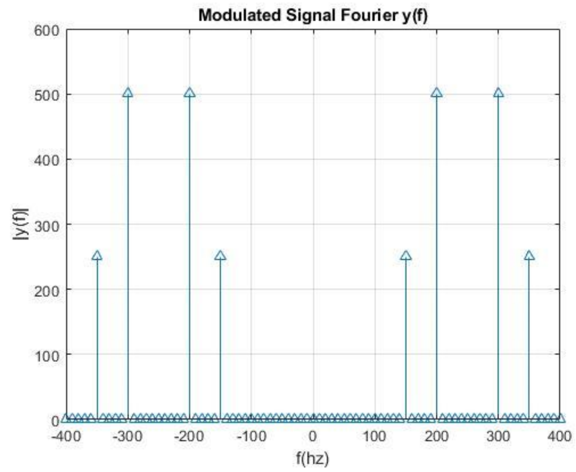
If Fourier Transform of y(t) is done;

$$Y(f) = 500[\delta(f-300) + \delta(f+300) + \delta(f-200) + \delta(f+200)] + 250[\delta(f+350) + \delta(f-350) + \delta(f-150) + \delta(f+150)]$$



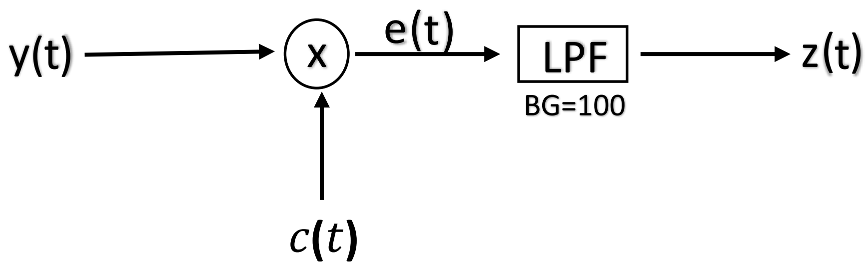
(Figure 5)

If the graph of Y(f) is drawn on Matlab;



(Figure 6)

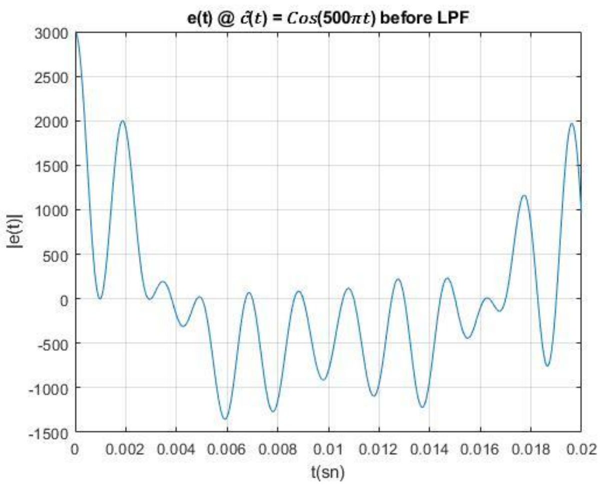
3) If the carrier signal generated at the demodulator is $\hat{c}(t) = Cos(500\pi t)$, plot the signal at the input of the LPF, $e(t)$ and its spectrum.



$$e(t) = y(t).\,\hat{c}(t)$$

$$e(t) = 500[\cos(2\pi 550t) + \cos(2\pi 50t) + \cos(2\pi 450t) + \cos(2\pi 50t)] + 250[\cos(2\pi 600t) + \cos(2\pi 100t) + \cos(2\pi 400t) + \cos(2\pi 100t)]$$

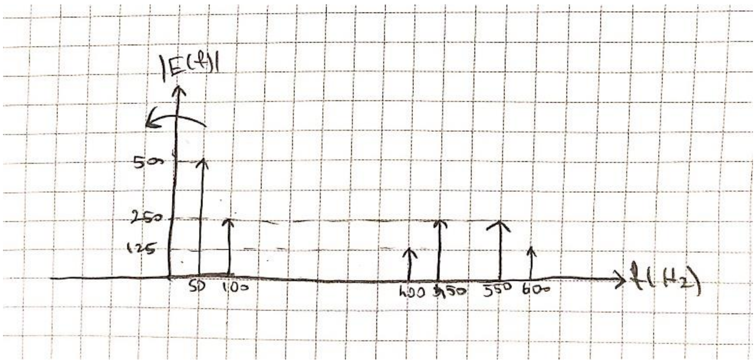
If the graph of e(t) is plotted on Matlab;



(Figure 7)

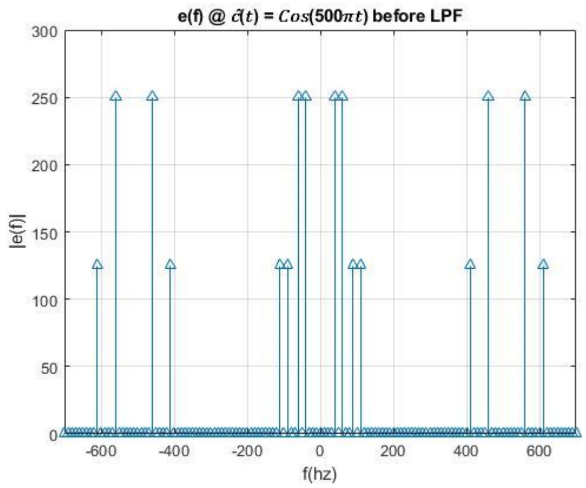
If Fourier Transform of e(t) is done;

$$E(f) = 500[\delta(f - 50) + \delta(f + 50)] + 250[\delta(f - 550) + \delta(f + 550) + \delta(f - 450) + \delta(f + 450) + \delta(f - 100) + \delta(f + 100)] + 125[\delta(f - 600) + \delta(f + 600) + \delta(f - 400) + \delta(f + 400)]$$



(Figure 8)

If the graph of E(f) is drawn on Matlab;



(Figure 9)

4) Plot the signal at the output of the LPF, $z(t)$ and its spectrum.

The bandwidth of the message signal m(t) is 100 Hz. So the low pass filter should have the same bandwidth. If we choose a filter with a bandwidth of 100 Hz, the signals between -100 and +100 pass through the filter, the signals in the other parts do not pass through the filter.

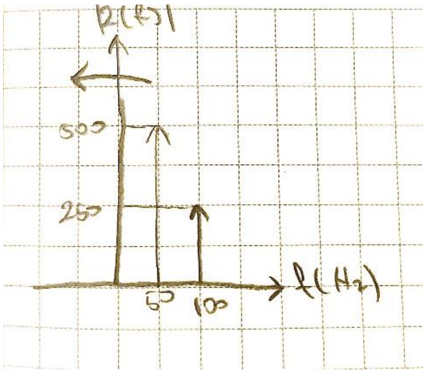
If such a filter is selected and applied to E(f) in the frequency domain;

$$E(f) = 500[\delta(f - 50) + \delta(f + 50)] + 250[\cancel{\delta(f - 550) + \delta(f + 550) + \delta(f - 450)} + \cancel{\delta(f + 450)} + \delta(f - 100) + \delta(f + 100)] + 125[\cancel{\delta(f - 600) + \delta(f + 600) + \delta(f - 400)} + \cancel{\delta(f + 400)}]$$

Strikethroughs do not pass through the filter. Other parts pass. That is, Z(f) is obtained as follows.

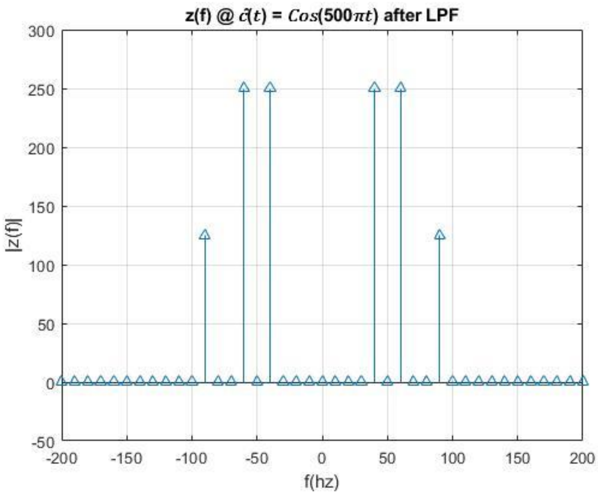
$$Z(f) = 500[\delta(f - 50) + \delta(f + 50)] + 250[\delta(f - 100) + \delta(f + 100)]$$

The graph of Z(f) obtained;



(Figure 10)

If this graph is drawn on matlab;



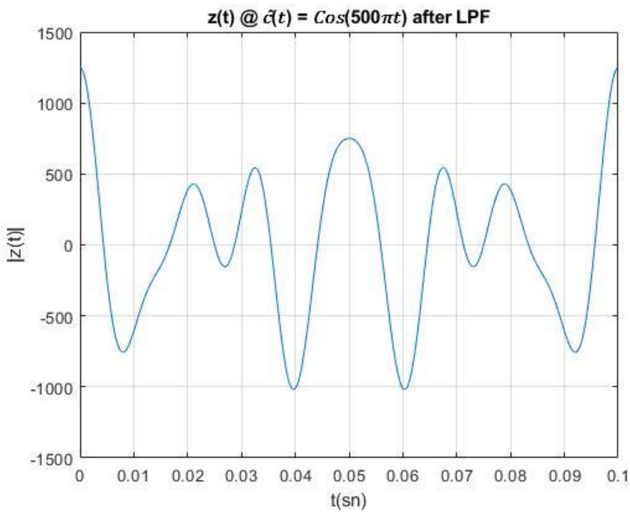
(Figure 11)

If the inverse fourier transform of the found Z(f) is taken, z(t) is found.

$$F^{-1}\big(Z(f)\big) = z(t) = 1000Cos(100\pi t) + 500Cos(200\pi t)$$

Max Value=1500

If this is plotted on matlab;



(Figure 12)

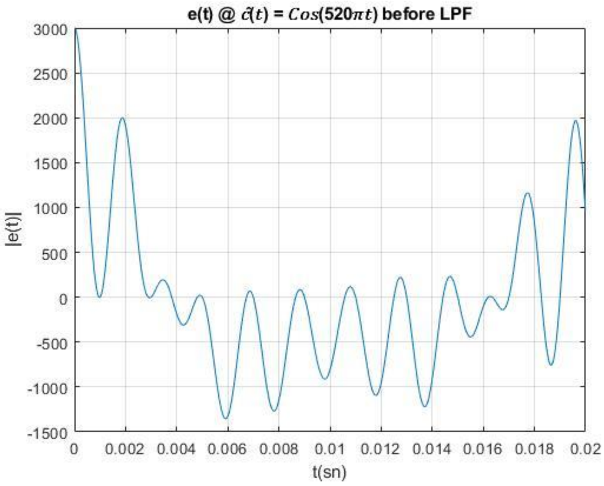
5) Repeat part 3 and 4 if $\hat{c}(t)$ = $Cos(520\pi t)$.

If $\hat{c}(t)$ = $Cos(520\pi t)$, the new e(t) is found as follows.

$$e(t) = y(t).\,\hat{c}(t)$$

$$e(t) = 500[\cos(2\pi 560t) + \cos(2\pi 40t) + \cos(2\pi 460\mathrm{t}) + \cos(2\pi 60\mathrm{t})] + 250[\cos(2\pi 610t) + \cos(2\pi 90t) + \cos(2\pi 410\mathrm{t}) + \cos(2\pi 110\mathrm{t})]$$

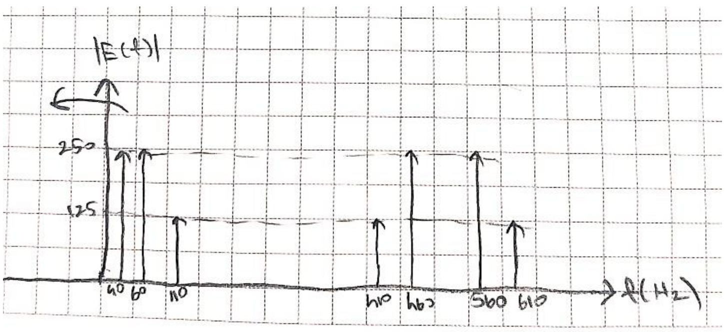
If the graph of e(t) is plotted on Matlab;



(Figure 10)

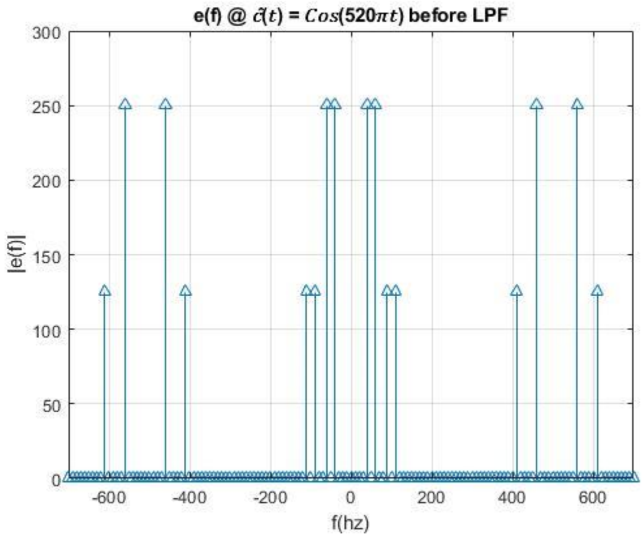
If Fourier Transform of e(t) is done;

$$E(f) = 250[\delta(f-560) + \delta(f+560) + \delta(f-40) + \delta(f+40) + \delta(f-460) + \delta(f+460) + \delta(f-60) + \delta(f+60)] + 125[\delta(f-610) + \delta(f+610) + \delta(f-90) + \delta(f+90)\,\delta(f-410) + \delta(f+410) + \delta(f-110) + \delta(f+110)]$$



(Figure 11)

If the graph of E(f) is drawn on Matlab;



(Figure 12)

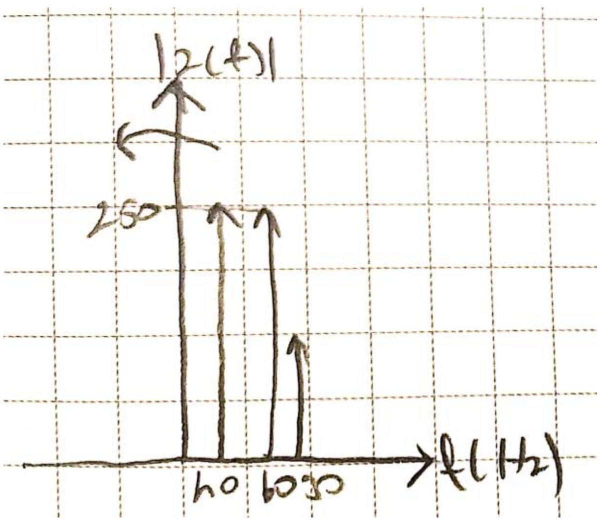
If the low pass filter is applied for the newly found E(f);

$$E(f) = 250[\cancel{\delta(f-560)} + \cancel{\delta(f+560)} + \delta(f-40) + \delta(f+40) + \cancel{\delta(f-460)} + \cancel{\delta(f+460)} + \delta(f-60) + \delta(f+60)] + 125[\cancel{\delta(f-610)} + \cancel{\delta(f+610)} + \delta(f-90) + \delta(f+90) + \cancel{\delta(f-410)} + \cancel{\delta(f+410)} + \cancel{\delta(f-110)} + \cancel{\delta(f+110)}]$$

Strikethroughs do not pass through the filter. That is, the new Z(f) is found as follows.

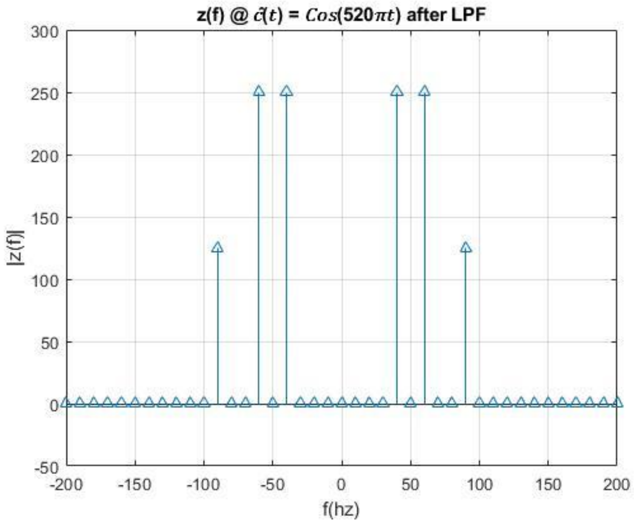
$$Z(f) = 250[\delta(f-40) + \delta(f+40)] + 250[\delta(f-60) + \delta(f+60)] + 125[\delta(f-90) + \delta(f+90)]$$

If this graph is drawn;



(Figure 13)

If the same graph is drawn on matlab;



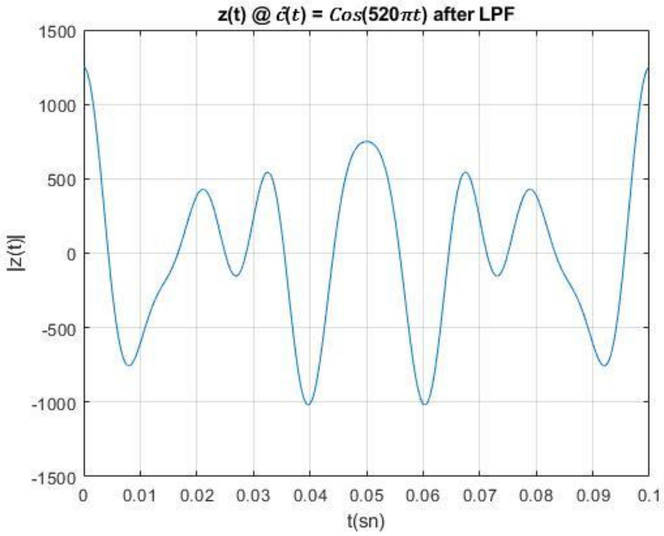
(Figure 14)

If the inverse fourier transform of the found Z(f) is taken;

$$F^{-1}\big(Z(f)\big) = z(t)=500\cos(80\pi t) + 500\cos(120\pi t) + 250\cos(180\pi t)$$

Max Value=1250

Graph of z(t) found;



(Figure 15)

6) Do all the steps above analytically, and compare to the simulation results and comment on them.

In this project, a given signal was first modulated and then demodulated, and graphics of the given signals in the time and frequency domain were obtained. These graphs are the same as the graphs made analytically.

MATLAB CODE:

```
.................MUHAMMET ASIM UYANIK.................
.....................1801022012.....................
clc;
clear all;

% Define Equations
Fs = 10^5;
Ts = 1/Fs;
t = 0:Ts:(5/50-Ts);
m = 20*cos(100*pi*t)+10*cos(200*pi*t); ...message signal
c = 100*cos(500*pi*t); ...carrier signal

% Message Signal m(t)
figure(1)
plot(t(1:2000),m(1:2000));
title('Message Signal m(t)')
xlabel('t(s)')
ylabel('|m(t)|')
grid on;

% Message Signal Fourier Transform m(f)
N = length(m);
f = linspace(-Fs/2-5,Fs/2-5,N);
MF = fftshift(fft(m)/N);
figure(2);
stem(f,abs(MF),'^');
title('Message Signal Fourier m(f)')
xlabel('f(hz)')
ylabel('|m(f)|')
grid on;
xlim([-200 200])

% Modulated Signal y(t)
yt = m.*c;
figure(3)
plot(t(1:2000),yt(1:2000));
title('Modulated Signal y(t)')
xlabel('t(sn)')
ylabel('|y(t)|')
grid on;

% y(t) Fourier Transform y(f)
Yf = fftshift(fft(yt)/N);
figure(4);
stem(f,abs(Yf),'^');
title('Modulated Signal Fourier y(f)')
xlabel('f(hz)')
ylabel('|y(f)|')
grid on;
xlim([-400 400])


% if c̃(t) = Cos(500πt)...........................
c1 = cos(520*pi*t); ...c̃(t)

% e(t) before LPF
et = yt.*c1;
figure(5)
```

```
plot(t(1:2000),et(1:2000));
title('e(t) @ c(t) = Cos(500πt) before LPF')
xlabel('t(sn)')
ylabel('|e(t)|')
grid on;

% e(t) Fourier Transform e(f)
Ef = fftshift(fft(et)/N);
figure(6);
stem(f,abs(Ef),'^');
title('e(f) @ c(t) = Cos(500πt) before LPF')
xlabel('f(hz)')
ylabel('|e(f)|')
grid on;
xlim([-700 700]);

% LOW PASS FILTER...
A = zeros(1,49990/10);
A(1:10)=1;
B=zeros(1,50000/10);
B(end-9:end)=1;
C=[B 1 A];...FILTER

% z(f) low pass filter
Zf=Ef.*C;
figure(7);
stem(f,Zf,'^');
title('z(f) @ c(t) = Cos(500πt) after LPF')
xlabel('f(hz)')
ylabel('|z(f)|')
grid on;
xlim([-200 200]);

% inverse fourier transform for z(f)
zt = N*ifft(ifftshift(Zf),N);
figure(8)
plot(t,zt);
title('z(t) @ c(t) = Cos(500πt) after LPF')
xlabel('t(sn)')
ylabel('|z(t)|')
grid on;


% ÇALIŞMADI
% A=[f;abs(Ef)];
% [sat,sut]=size(A)
%
% for i=1:sut+1
%     if A(1,i)<=-100 | A(1,i)>=100
%         A(2,i)=0;
%     end
% end
%
% figure(7);
% stem(f,A(:,2));
% title('z(f) @ c(t) = Cos(500πt) after LPF')
% xlabel('f(hz)')
% ylabel('|z(f)|')
% grid on;
```

```
% xlim([-1000 1000]);



% if c(t) = Cos(520πt).........................
c2 = cos(520*pi*t); ...new c(t)

% e(t) @ c(t) = Cos(520πt)  before LPF
et1 = yt.*c2;
figure(9)
plot(t(1:2000),et1(1:2000));
title('e(t) @ c(t) = Cos(520πt) before LPF')
xlabel('t(sn)')
ylabel('|e(t)|')
grid on;

% e(t) @ c(t) = Cos(520πt) Fourier Transform e(f)
Ef1 = fftshift(fft(et1)/N);
figure(10);
stem(f,abs(Ef1),'^');
title('e(f) @ c(t) = Cos(520πt) before LPF')
xlabel('f(hz)')
ylabel('|e(f)|')
grid on;
xlim([-700 700])

% Low pass filter for e(f)
Zf1=Ef1.*C;
figure(11);
stem(f,Zf1,'^');
title('z(f) @ c(t) = Cos(520πt) after LPF')
xlabel('f(hz)')
ylabel('|z(f)|')
grid on;
xlim([-200 200]);

% inverse fourier transform for z(f)
zt1 = N*ifft(ifftshift(Zf1),N);
figure(12)
plot(t,zt1);
title('z(t) @ c(t) = Cos(520πt) after LPF')
xlabel('t(sn)')
ylabel('|z(t)|')
grid on;
```